cially lamentable, because in its absence they lose the valuable assistance of amateur workers, who might be an effective substitute for the students of an academic study. In no subject are there more volunteers, who take an active part in observing, than in meteorology; but how few of them carry their work beyond the stage of recording observations and taking means. The reason is not lightly to be assigned to their want of capacity to carry on an investigation, but far more, I believe, to the want of knowledge of the objects of investigation and of the means of pursuing them.

Among the agencies which in the past have fostered the knowledge of these subjects, and stimulated its pursuit, there stand out prominently the annual meetings of this association. It was the British Association which in 1842 re-founded the Kew Observatory for the study of the physics of the atmosphere, the earth, and the sun. It was the British Association which promoted the establishment of magnetic observatories in many parts of the earth, and in the early sixties secured the most brilliant achievements in the investigation of the atmosphere by means of balloons. I know of no other opportunity of anything like the same potentialities for the writers of papers to meet with the readers, and to confer together about the progress of the sciences in which they are interested. But its potentialities are not realized. Those of us who are most anxious for the spread of the application of mathematics and physics to the phenomena of astronomy, meteorology and geophysics have thought that this opportunity could not properly be utilized by crowding together all the papers that deal with such subjects into one day, or possibly two days, so that they can be polished off with the rapidity of an oriental execution. In fact, the opportunity to be polished off is precisely not the opportunity that is wanted. There are some of us who think that a British Association week is not too long for the consideration of the subjects of which a year's abstracts occupy a volume of six hundred pages, and that, if we could extend the opportunity for the consideration of these questions from one or two days to a week, and let those members who are interested form a separate committee to develop and extend these subjects, the British Association, the country and science would all gain thereby. I venture from this place, in the name of the advancement of science, to make an appeal for the favorable consideration of this suggestion. It is not based upon the depreciation, but upon the highest appreciation of the service which mathematics and physics have rendered, and can still render, to the observational sciences, and upon the well-tried principle that close family ties are strengthened, and not weakened, by making allowance for natural development.

The plea seems to me so natural, and the alternatives so detrimental to the advancement of science in this country, that I can not believe the association will turn to it a deaf ear. W. N. SHAW

GRAPHIC ART IN SCIENCE[1]

As a beginning I wish to thank this society for the privilege granted me to address it. That a strong personal pleasure is felt at this opportunity, I shall not attempt to deny; but I have a greater satisfaction than this, and that is that I am allowed to present a subject which has been too seldom publicly discussed in the presence of investigators and students, viz.: the part played by graphic art in science.

This subject is one of growing importance, and I trust I shall live to see the day

[1] Read before the Harvey Club, University of California, November 7, 1907.

when every student of the natural sciences will be obliged to take a thorough course in drawing as adapted to his own special requirements. And I hope, as well that this course will be so arranged that the student will understand at least the *theory* of the several processes by which the printer reproduces a drawing. In fact, I wish this address to be considered as a stroke toward that end.

Just when the first drawing was made to illustrate an idea, of course, can not be determined. Perhaps it was nothing more pretentious than a simple sketch, fashioned with a sharpened twig upon some smooth bit of sand. From such a small beginning, however, graphic art has developed prodigiously, and to-day it forms a large integer in nearly every branch of science. In view of this, almost every university of repute, both in this country and abroad, employs a salaried scientific artist. At Johns Hopkins, in Baltimore, where is situated perhaps our best medical college, an actual corps of expert artists is kept busily employed in illustrating scientific articles there produced.

But this growth has not been unattended with set-backs. Graphic art has not won its place in scientific work without many a bitter struggle. In truth, even at this late date there are, unfortunately, many investigators doing exceptionally good work, who do not appreciate the highest type of drawing, and actually refuse to include it in their publications.

This folly can not be attributed to any personal aversion entertained towards fine art, it is simply the result of ignorance. These individuals have not been properly trained to see the good points in realistic drawing, and, not being by nature of an artistic trend, they simply refrain from adopting something they can not understand. As an example of this occasional "tiff" between realistic and diagrammatic representation of scientific work, the following experience of a student with a "hard-headed man of science" might be cited:

All the drawings made in the zoological laboratory of this particular school were being done in black-and-white, but the student felt that if drawing has any value at all in the study of zoology, it should be to direct the observer's attention to *all* the features of the object examined—its *color* as well as its *morphological* characteristics. Accordingly, he brought a color box with him one day into the laboratory, and started to draw a certain preparation with as near the same color-variations presented as his talent permitted. This drawing soon attracted admiring glances from the other students engaged in the laboratory. When it was about completed, the principal of the school, the "hard-headed man of science" approached the "realist," and said with some asperity: "This is not an art-academy, this is a zoological laboratory. You had better make your drawings in simple black-and-white." Had the astonished student been behind in his work, had his respect for realism produced a bad effect on the decorum of the class, or had his drawing not been the best in the laboratory, I think he would have been honest enough to have taken the principal's advice. But none of these things were so. In consequence he thought the excellencies of his product sufficient justification for its novelity, and, without laying down his brush, he answered respectfully but firmly: "If science does not approve at present of life-like illustrations, the day *must* come when it will!" The principal made no reply and walked away with a frown. The student found out afterwards, however, that he was no innovator, as very excellent scientific drawings in color had been made a good hundred years before that old fellow was

born. But the old man has never changed his view-point, and to this day a schematic drawing, done in sober black-and-white, remains the only kind of scientific illustration that he can tolerate. And yet he has done some very good investigative work, is an excellent educator of considerable reputation and has been successful in the financial side of life. So, he can not be counted below par in mental attributes. He was simply not properly trained to appreciate the value of realistic drawing. Let us guard against such a poverty of understanding in ourselves, and, by word and example, help root it out of others with whom we come in contact.

It is hardly necessary to defend the practise of drawing as an adjunct toward explaining an idea, as surely every one here has convinced himself of that fact long ago, even while reading an ordinary daily newspaper. And much more welcome is an illustration in some complex scientific discussion, where words alone so often fail completely to tell the story, or merely give a faint outline of what the observer wishes to convey. But, until quite recently, the practise of drawing was not accorded its deserved recognition in the *teaching* of scientific subjects. What physician of fifty years ago was obliged to systematically draw the bones he studied? Or, what one of thirty years ago was obliged to draw the preparations he investigated with the help of high-power lenses? Comparatively, they were good men, it is true, but one can always improve, and at this time there is hardly a medical school of any merit where drawing is neglected as part of the routine laboratory work, and this is a very happy condition, indeed, for it exacts the closest scrutiny of objects examined by the student. His attempt to picture on paper some particular object reveals characteristics of that object which would assuredly have escaped his observation if its graphic illustration were not exacted.

But, in spite of this general recognition accorded to drawing as a teaching method, as far as I can learn, there is not a single text-book or laboratory guide of any practical completeness in microscopical drawing, and this is only one division of graphic art as employed in the scientific world. Students in the laboratory are told to get this pen or that, this grade of pencil, such and such a kind of ink and paper. Perhaps blenders, erasers and thumb-tacks are alluded to. But, aside from this, the beginner seldom receives further instruction as to how he is to go about the difficult task of drawing what he sees through the microscope. His looks and actions often show how much he would welcome any advice concerning a method of approaching this new work. He is alone in a strange country without a road in sight.

Feeling that something should be done to contend against this unfortunate state of affairs, I determined to prepare a short description of some materials and methods commonly used in the drawing of microscopical preparations, and Professor Hardesty has thought this sufficiently worthy to give it a place in his "Laboratory Guide in Histology."

The condition should prevail, however, that when a student has brought his career so far forward as to be admitted to the study of medicine, he should then be trained already in microscopical drawing. He has so much to do in this highly complex problem that the extra time spent in acquiring an illustrative technic is given at the expense of more important matters.

Let us now drop the student and his troubles for a time, and turn to the field where graphic art finds its most dignified and important employment in the sciences, that is, in the illustration of investigative and teaching publications.

For its practise in these spheres, allow me to emphasize that no one should be chosen except talented and well-trained artists. It is to be lamented that such artists are not made use of to any great extent to-day. A merely superficial acquaintance with some otherwise very good modern text-books and current scientific literature is quite sufficient to prove this statement. And, at a glance, it is rather difficult to understand why such should be the case. In fact, a number of obstinate conditions contribute to the matter. First of all, only in rare instances has the investigator the adequate financial support at his disposal to pay for the services of first-rate artists. Secondly, under the existing conditions first-rate artists can not be supplied in fitting numbers to fill even the available positions. And thirdly, the investigator is too often one who underrates, or does not appreciate, the value of realistic drawing.

Of these obstacles perhaps the financial one is the most common and difficult to contend against. Scientific text-books are used by such a comparatively small public that the publisher is compelled to cut down the expenses of their production to the lowest allowable figure. Otherwise his limited profit would be lost. And, with this economy, the illustration of text-books is very likely to suffer most. Good artists must be fairly well paid, and, to retain the merits of good drawing, somewhat expensive methods and a fine grade of paper are necessary in the reproduction by the printer. To raise the price of a book to any considerable degree, because of the extra expense its illustration has entailed, is apt to be risky, for already the student and investigator groan aloud under the price they are obliged to pay for additions to their professional libraries. And yet, knotty as it seems, much can be done towards solving this problem, and the best way to commence the task is by employing only *competent* artists. A skilful artist can tell a story more convincingly with fewer illustrations, and in a technic which will allow a cheaper method of reproduction, than an artist whose talent is but moderate and whose training has been mediocre. A second-rate artist is apt, as well, to be a slow one. Not alone does he waste time in the actual drawing of the object, but it is only too often the case that the investigator or editor is forced to spend considerable valuable time in explanation before an inferior artist grasps the idea to be conveyed by an illustration. Occasionally, even then one is not through with this type of artist, for, while he may have seemed to understand what was wanted, he will return with a drawing that is entirely erroneous, and the whole trying performance must be gone through with again. Thus, economy in the matter of artists frequently amounts to nothing but unpardonable extravagance.

Leaving text-books and their problems, let us turn attention to the vehicles through which investigators disseminate their findings. These journals are, for the most part, conducted by scientists, and there is seldom the hope among them that the journal will bring in more than enough to pay for its publication. So, profit falls out of the argument entirely, with sometimes a consequent increase in the facilities for elaborate illustration. It is only now and then the case that an editorial staff of such a journal will balk at any reasonable expense necessary to reproduce the drawings explanatory of the text in a piece of research. Accordingly, aside from the limited funds at the investigator's command, there is hardly any reason left why the very best artist should not be employed to illustrate his work. Most of the institutions, which exist merely for the furtherance of science, though running at about the utmost limit of their financial resources, consider the

occasional use of an artist, perforce, as a sort of necessary evil. But the little money at disposal for his pay oftentimes precludes the services of a capable and experienced man. Yet, if the employment of inferior artists in the production of text-books is, in the end, a form of extravagance, it is doubly so in the illustration of purely investigative labor. The very fact that the observer so frequently calls in graphic art to assist in his presentation of a study, proves that he feels there are certain clefts in the description of this study which words can not bridge over. He needs an *optical* picture. If this optical picture is not just as he sees it in his preparations, there is bound to be a conflict between it and his text, which is bound to confuse rather than enlighten the reader. Therefore, the *best* drawing should be utilized, and *only* the best. But again comes the discouraging complaint: "How is the best drawing to be obtained when sufficient funds are not at hand to employ a good artist, and with hardly enough for a poor one?" This condition will exist until the investigator throws aside his lukewarm attitude in the matter, and takes up an earnest campaign towards furnishing the necessary money for the employment of his indispensable ally, viz.: the finished scientific artist.

I can recall instance after instance where an investigator has worried through weeks and even months of vexation with an inferior artist, and, as soon as the illustrative work was completed, forgotten all about his trials until it became necessary to call upon the illustrator for the needs of another publication. In the period of suspended graphic activity no attempt was made by the investigator, or at best, only a feeble, abortive one, to supply a competent artist. Every facility, on the other hand, would be called into play to supply the laboratory paraphernalia requisite to the proper pursuance of investigative procedures, but the artist, secondary only to the text in the publishing of this investigation, had been almost completely overlooked. Now who is to know about this desired help if the individual who needs it most does not give it expression? A faculty is not to be censured if it does not take steps towards allowing each research laboratory under its dominion the financial means to emply a capable artist, if the director of that laboratory has not vigorously presented his need of one. Granting that the available funds of an institution are not plentiful enough to allow the installation of a trained scientific artist in any one or in the different departments of investigation, the heads of the departments should see to it then that no opportunity passes to bring this keenly felt want before the consideration of wealthy, public-spirited individuals who are able to contribute towards its dissipation.

With the establishment of paying positions, and schools for their proper training, to be described later, there can be no doubt that the number of skilled, scientific artists would rapidly increase. Further, the number of scientific artists who, at present, do not understand the immense advantages offered by a high type of realistic graphic art would speedily diminish by the coming in contact with those who are able and determined to practise it.

In the preceding remarks, frequent reference has been made to realistic graphic art, or realistic drawing. These terms should be self-explanatory, but, not wishing any confusion to arise, a fairly exhaustive discussion of them will be hardly superfluous.

Let us suppose that nothing more complex is to be represented than an ordinary bottle, standing on a table and at some distance from, although in, the unob-

structed light of a window. It is quite true that any one would know what sort of an object the artist intended to picture, if only the correct, bare outlines of this bottle were drawn. These outlines would suggest a bottle, nothing but a bottle, yet with very little of its special characteristics. But an outline drawing of it would not be a type of realistic drawing, for even the most imaginative person could not find any similarity between the bottle and the drawing, save in the outline. Now suppose that the outline drawing be filled in with the proper shading to give it the appearance of being round, a step towards realism would therewith have been taken; but, in spite of that, the drawing is still far from being a good example of graphic art. Comparing it with the bottle in a critical way, one could not honestly and irrefutably identify one with the other, for, as example, this shading, directed alone towards showing that the bottle is round, does not develop the fact that the bottle's surface is highly polished and hence *reflective*. Continuing, however, the subtleties of shading to the degree where the light reflected from the table on to the bottle, and *vice versa,* is shown, to where the source of light, namely, the window, with its typical cross sashes, is seen in miniature upon the smooth glass, and to where other characteristics have been added, the drawing has at last reached the fullness of realism, it has become, in a manner, a *portrait*. Any one now would recognize at a glance what *particular* bottle the drawing was intended to represent, providing, of course, that one compared it with the bottle under the same conditions of position and lighting.

This very humble subject, a smooth, highly polished bottle, has been taken to illustrate realistic drawing, since its characteristic of reflection is shared by some forms of laboratory specimens subjected to certain conditions. Yet, the greatest scientific artist in this country has been severely criticized by some investigators because, at times, he allows his source of light, a near-by window, to appear in his drawings, as it clearly did on the reflective surfaces of the objects drawn.

There is a common enough belief in scientific circles that any feature of a drawing not directly contributing to the main idea which an investigator wishes to express, must be looked upon as a blemish. And this is true to some extent. But the main idea seldom exists severely alone, unsupported by secondary ones. As a matter of fact, in nearly all instances, a main idea might be considered as an accumulation of associating secondary ideas. The particular artist mentioned above realizes this truth, and for those who share his belief, the delineation of secondary ideas never disturbs, but, on the contrary, markedly assists in his forcible expression of the central thought. To cite an example:

Turning to a certain page of a recent, scientific text-book, we find a drawing of a cyst by this particular artist whose realism has been, as remarked, criticized by a number of competent investigators. In the text describing the cyst, from which this drawing was made, the author states that its surface was very smooth and moist. For the benefit of those who do not know what a cyst is, it might be generally described as a closed sack, more or less globular in form, its walls consisting of organic matter, and filled with more or less fluid contents. Any surface, whether organic or inorganic, if it be *very smooth* and *moist,* is bound to be *reflective*. Now, whether this surface reflect the source of light, to which it is subjected while being drawn, or some feature of the plane upon which it rests, or some other near or distant object, is quite a

matter of choice; but some recognizable thing must be pictured on the surface to show that it is reflective, if in a high degree. This was the case with the cyst described by this particular author and drawn by this particular artist. Now why should the artist be criticized because he chose his source of light, the window, as the object reflected, providing, of course, that it did not obscure any structural detail described by the author? In this instance it did not obscure. By drawing in his source of light, the window, since he had to do with a highly reflective surface, he simply introduced a secondary fact which largely contributed to, without detracting from, the main idea, and he added thereby only a touch of *realism* to his picture.

Now you may ask why has so much stress been laid upon this *realism* as applied to graphic art in science? The answer to that question may be begun with another question—Why is there such a pursuit as scientific investigation? Surely one of its chief reasons for existence is to dispel the mystery that often overclouds even the simplest phenomena of life, and to lead us, if not into the full, white light of complete understanding, at least, into the light of partial comprehension. And often when one seeks to describe some findings that have resulted from his exploration into the unknown, he finds that his words are too vague and inadequate to present the complete and correct description. He desires to convey to others a delicately accurate idea of the object as he sees it, and naturally must turn to the use of a picture. Therefore, an investigator should never tolerate a drawing illustrative of his text that does not vividly contribute to express, in an optical sense, completely and truthfully, the object described.

But, even realism can be carried too far in the drawing of scientific subjects, and to avoid this a fine discrimination is necessary: a discrimination that the artist can not be expected to exercise if he does not know *what* he is drawing, and, more important, the *purpose* of the drawing. This leads us to what I consider the most momentous matter in this address, and that is a discussion of the ideal relationship which *should* exist between scientist and artist, and the means by which this might be effected. At present it is only too common that inharmonious relations exist between scientist and artist.

In the first place, an individual whose nature has led him into a life devoted to investigation is seldom an adept in the use of tools employed in the practise of graphic art. At times it seems that investigative talent, and the talent necessary to worthily render anything in a graphic way, are natural antagonists, so rarely are they found inculcated in the same person. But there are very few good scientists who, if they choose and have the opportunity, can not become excellent critics of the good and bad points in a drawing or painting, especially when it is used to illustrate subjects with which their business in life has made them thoroughly familiar.

And, on the other hand, very few artists display any taste for or merit in work of a purely investigative character. Most of them are loath to believe that any high art can be worked into subjects that present a pattern of almost infinite detail. But this is not all. Without the proper guidance, even an eager, capable artist set upon the task of drawing some scientific subject, would be, in nearly every instance, sure to give some important feature of the same only an indifferent expression, or omit it entirely, while another one, perhaps an artifact, something that a horde of accidental conditions might produce and which is entirely foreign to the subject in its natural state, would be painstaking and conspicuously copied, thus rendering his production

absolutely useless to the scientist. So the scientist with little artistic talent, and the artist with no scientific training, clash together again and again, leading to a loss of precious time, and a severe straining of patience on both sides. This thundercloud hangs over both until, by constant rubbing together, each takes on some of the other's particular efficiency. Under the conditions existing to-day, this is a slow and laborious process, and frequently attended with exhibitions of the most fretful behavior on the part of both principals. The scientist gets angry with the artist, and *vice versa,* each consoling himself with the firm conviction that the other is a microcephalic egotist. And this is not so strange as at first appears when we look at the methods by which each has attained his smattering of the other's specialty. The scientist, in the course of his career, because of the demands laid upon him by the publishing of his work, is, from time to time, brought into brief and, as a rule, imperfect contact with the processes by which a drawing or painting is reproduced in printed literature. He hears about light and shade, color and tone values, contour and perspective, half-tone and auto-type, etc., until he has learned them by heart, and only with a ghost of an idea what they all mean. Hence, he can not be a judge of what particular process of illustration best adapts itself to the subject described, and when a skilled artist points out the respective merits of different processes of delineation and reproduction, he finds that his words fall on, at best, only partially comprehending ears. Yet the artist may be just as far in arrears in his scientific obligations. It is a long, hard struggle for him to suppress his realism to the interest of the scientific purpose of an illustration. Time and time again he spends fond hours with some particular thing he sees in the preparation, only to have it ruthlessly cut out by the investigator as a positively unnecessary and confusing feature in the drawing. And it is no uncommon occurrence to see an artist presenting himself for service in scientific circles, boasting of nothing more than a bowing acquaintance with the microscope. He looks into it with a squint, sends the oil-immersion lens down through the cover-glass, and carries the instrument about by its delicate adjusting-mechanism.

Coming to the question of what should be done to improve the relations existing between scientist and artist, the terse advice of Max Brödel sums up the whole problem—"Teach the scientist more art and the artist more science." And how is this to be done? I can see but one logical way, and that is by modifying and establishing courses where both scientist and artist may be trained in a proper and thorough manner concerning what each should know of the other's occupation. From the best available sources of information I am told that such a school is nowhere in existence to-day. Here is an opportunity for this university to take up an initiative which it would never need to regret. For, with the proper management, I am sure that such a course of instruction would be nearly, if not quite, self-supporting, and the good results to be obtained from it would earn the hearty thanks of every branch of scientific work coming within the pale of its influence. This is not the time or place to discuss the equipment or conduction of such a course of study. Suffice it to say that neither would demand heavy financial expenditure. While the mature scientist and mature artist would have, naturally, recourse to the training here offered, the greatest bulk of its attendance would be from the ranks of the beginners

in both pursuits. The students of natural sciences could be here enrolled in their several classes, and instructed in the graphic arts as demanded by their own special needs. And individuals of graphic talent, those intending to follow the illustration of scientific subjects as a life-work, could be here instructed in a manner calculated to amply fit them for the graphic execution of any subject in any branch of scientific investigation. At least two courses, experimental and didactic, would be attended by both sections of workers, viz.: reproductive methods, that is, the various processes by which a drawing or painting is published, and a systematized explanation of that ideal relationship which *must* exist between scientist and artist to insure the best results. The mere mention of these two courses calls up to mind a generous number of subjects embraced by them, each one of which, if anything like justice were done it, would require more time than is allowed to any single period of discussion. But, and I have no doubt at all as to the truth of this assertion, every one, be his help great or small, who assists towards raising the institution from the *suggested* to the *realized* will have done every form of scientific work a great service.

In closing this effort towards bringing art and science into closer, more effective affiliation, I could hardly find a higher sentiment, or an example of nobler support of this cause, than that expressed in a recent personal communication from Mr. Max Brödel, the most capable of all the artists engaged in illustrating American science to-day. They run as follows:

> The only course on the subject of medical illustration is given by myself, and is limited to a few individuals. I don't wish to leave this world without having done some good, and I believe I can help the beginner in the study of medical illustrations to avoid a great many pitfalls and disappointments. There is not a penny in it for me, but I do it because I think it is my duty towards the medical profession.

A. W. LEE

UNIVERSITY OF CALIFORNIA

THE MARINE BIOLOGICAL STATION OF ROSCOFF. ANNEX OF THE UNIVERSITY OF PARIS

A CIRCULAR received some time ago from Professor Delage concerning the Marine Laboratory at Roscoff, seems worthy of reproduction in SCIENCE in order that the advantages of the station may be brought to the attention of American students who may be intending to pursue zoological studies abroad.

J. PLAYFAIR MCMURRICH

Founded in 1872 by H. de Lacaze-Duthiers, this station had at its beginning only a rudimentary equipment. But the judicious selection of its site was a certain guarantee of its ultimate development, for in its immediate neighborhood all varieties of sea bottom are to be found, with the fauna and flora characteristic of each; indeed, there are few points, either in France or abroad, that can compare with it in the richness and variety of their fauna. In addition the tides are very high (almost 10 meters) and expose a large extent of shore, so that the collection of quantities of material is very easy.

The progress of the station has been continuous and to-day it is a vast establishment whose buildings cover the extent of a demi-hectare and comprise a large aquarium with 300 square meters of floor-space and containing 20 aquaria and 2 large basins, all supplied with a constant circulation of sea water; an aquarium of nearly 1,000 square meters of surface and 4 meters in depth, supplied by the tide; elevated tanks of 180,000 liters capacity for the supply of the large aquaria and the smaller ones in the work-rooms; 22 work-rooms for students carrying on original researches; a museum containing examples of all the animal forms of the region, identified by specialists; a large hall for students, in which two courses of lectures and laboratory work, each consisting of thirty sessions, are conducted; a library; a physical laboratory; a chemical laboratory; two photographic rooms; an engine room; a workshop; and twenty living rooms for investigators who may find it necessary to live in close proximity to their work.

The equipment also includes several small sail-